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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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10/538,306

06/09/2005

Makoto Ueki

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SUGHRUE MION, PLLC  
2100 PENNSYLVANIA AVENUE, N.W.  
SUITE 800  
WASHINGTON, DC 20037

EXAMINER

ARORA, AJAY

ART UNIT

PAPER NUMBER

2892

MAIL DATE

DELIVERY MODE

07/24/2008

PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

<b>Office Action Summary</b>	<b>Application No.</b> 10/538,306	<b>Applicant(s)</b> UEKI ET AL.	
	<b>Examiner</b> AJAY K. ARORA	<b>Art Unit</b> 2892	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 03 April 2008.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 7-19 and 21-25 is/are pending in the application.
- 4a) Of the above claim(s) 7-16 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☐ Claim(s) 17-19 and 21-25 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
  - ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)          | 4) <input type="checkbox"/> Interview Summary (PTO-413)           |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____                                      |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)          | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date _____  | 6) <input type="checkbox"/> Other: _____                          |

## DETAILED ACTION

### ***Claim Rejections - 35 USC § 112***

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

2. Claims 17-19 and 21-25 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

3. Amended claim 17 appears to recites at least four distinct elements: “an additional element to be added into the polycrystalline Cu film” (see lines 4-5 of the claim); “a barrier layer” (6<sup>th</sup> last line of the claim), “a barrier metal” (2<sup>nd</sup> last line of the claim), and “a barrier metal film” (2<sup>nd</sup> last line of the claim). Applicant’s amendment canceling “the” in favor of “a” appears to stress the distinctness of the above four elements. Further, the last two of the above identified four distinct elements must also meet the limitation that “a barrier metal at the interface between a barrier metal film and the polycrystalline copper alloy has not been oxidized”. The above was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art

that the inventor(s), at the time the application was filed, had possession of the claimed invention.

4. Similarly, amended claim 18 appears to recites at least four distinct elements: "an additional element to be added into the polycrystalline Cu film" (see lines 4-5 of the claim); "an oxide of the additional element" (4<sup>th</sup> last line of the claim), "a barrier metal" (2<sup>nd</sup> last line of the claim), and "a barrier metal film" (2<sup>nd</sup> last line of the claim). The above was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

5. Similarly, amended claim 19 appears to recites at least three distinct elements: "an additional element to be added into the polycrystalline Cu film" (see lines 4-5 of the claim), "a barrier metal" (2<sup>nd</sup> last line of the claim), and "a barrier metal film" (2<sup>nd</sup> last line of the claim). The above was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

6. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

7. Claims 17-19 and 21-25 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 17 recites (page 6, last two lines of

claim 17) recites the limitation "a barrier metal at the interface between a barrier metal film and the polycrystalline copper alloy" (emphasis added). There is insufficient antecedent basis for the limitation in the claim. Whereas the claim previously recites "polycrystalline copper alloy", the claim does not previously recite an "interface between a barrier metal film and the polycrystalline copper alloy"; and hence there is insufficient antecedent basis for the limitation "the interface" in the claim. The above also applies to claims 18 and 19 (refer to last two lines of each claim).

For the purpose of examination, the limitation would read as "an interface".

### ***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

8. Claims 17-19 and 20-25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Andricacos et al. (IDS reference EP 0751567 A2), hereinafter Andricacos, in view of Lee (US 2004/0188850), hereinafter Lee-850, and further in view of Fitzsimmons (US 2003/0155655), hereinafter Fitzsimmons.

Regarding claim 17, Andricacos (refer to Figures 3) teaches a copper alloy for wiring (Col. 5, lines 31-36) formed by

forming a polycrystalline copper alloy comprising copper and an additional element (Col. 4, lines 14-16, Col. 5, lines 49-54 and Col. 6, lines 41-44), irrespective of whether the alloy is formed by the recited process steps or not (see explanation below), wherein

concentration of the additional element is, at grain boundaries of crystal grains composing the polycrystalline copper alloy and in vicinities of grain boundaries, higher than that of the inside of the crystal grains, a barrier layer (22) is formed to surround the polycrystalline copper alloy, and concentration of the additional element is, at the interface between the polycrystalline copper alloy and the barrier layer and in vicinities of said interface, higher than that of the inside of the crystal grains (Col. 6, lines 41-44).

However, Andricacos does not teach that the additional element that is diffused into the copper film via grain boundaries is at least one of the claimed group. Lee-850 teaches a copper interconnect member wherein an additional element that is diffused into the copper film via grain boundaries is at least Zirconium (page 3, para 0021, last two sentences and para 0022). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the invention of Andricacos so that an additional element that is diffused into the copper film via grain boundaries is at least Zr (Zirconium). The ordinary artisan would have been motivated to modify Andricacos for

at least the purpose of maintaining a low electrical resistivity of the interconnect member (refer to Lee-850: page 3, para 0021, last two sentences).

Further, Andricacos does not specifically teach that “a barrier metal at the interface between a barrier metal film and the polycrystalline copper alloy has not been oxidized”. Fitzsimmons (refer to Figures 1A-1C) teaches a metal contact which may comprise copper (page 4, para 0064, 4<sup>th</sup>-5<sup>th</sup> sentence) and associated barrier metals such that a barrier metal (22, see Figure 1B) at the interface between a barrier metal film (18, see Figure 1B) and the metal contact (12V, see Figures 1A and 1B) has not been oxidized (because the presence of getter layer 20, see Figure 1B, prevents oxidation, see page 3, para 0040). Therefore, it would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that a barrier metal at the interface between a barrier metal film and the polycrystalline copper alloy has not been oxidized. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of preventing degradation of a semiconductor device (see Fitzsimmons, page 3, para 0037, 0040-0042) of which the metal contact may form an interconnect.

Note that claim 17 is a product claim but parts of the claim recite process limitations. Examples of such process limitations include the specific process steps or sequence of process steps for forming the polycrystalline copper alloy, as recited in claim 17, or the use of a specific process (like “gettering”) or its timing (as suggested by the limitation

“simultaneously”) in claim 17 (see page 6, lines 3-4). Therefore, these claims amount to product by process limitations, which will not be given patentable weight. *“Even though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process.” In re Thorpe, 777 F.2d 695, 698, 227 USPQ 964, 966 (Fed. Cir. 1985). See MPEP 2113.*

Regarding claim 18, Andricacos (refer to Figures 3) teaches a copper alloy for wiring (Col. 5, lines 31-36) formed by

forming a polycrystalline copper alloy comprising copper and an additional element (Col. 5, lines 49-54 and Col. 6, lines 41-44), irrespective of whether the alloy is formed by the recited process steps or not (see explanation below), wherein

the additional element is at least tin (Col. 5, lines 31-36)

concentration of the additional element is, at grain boundaries of crystal grains composing the polycrystalline copper alloy and in vicinities of grain boundaries, higher than that of the inside of the crystal grains (Col. 4, lines 14-19 and Col. 6, lines 41-47), and

a barrier metal film (Ta, see Figure 3) is formed on the polycrystalline copper alloy,



However, Andricacos does not disclose that “an oxide of the additional element is formed at said grain boundaries and/or in vicinities of said grain boundaries”. Lee-850 discloses compositions for forming wiring comprising copper (and associated copper grain boundaries) to which an additional element (or alloy element) is added, such that an oxide of the additional element (or alloy element) is formed at said grain boundaries and/or in viscinities of said grain boundaries (page 1, para 004, last sentence; page 2, para 0009 and page 4, para 0032, 1<sup>st</sup> four sentences). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that an oxide of the additional element is formed at said grain boundaries and/or in vicinities of said grain boundaries. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of to preserve low resistivity of the wiring (see Lee-850, page 4, para 0032, 3rd and 4th sentence; also see page 2, para 0009).

Further, Andricacos does not specifically teach that “a barrier metal at the interface between a barrier metal film and the polycrystalline copper alloy has not been oxidized”. This limitation has already been addressed in claim 17 in view of Fitzsimmons.

Note that claim 18 is a product claim but parts of the claim recite process limitations (similar to claim 17). Therefore, as explained for claim 17, the claim amounts to product by process limitations, which will not be given patentable weight.

Regarding claim 19, Andricacos (refer to Figures 3) teaches a copper alloy for wiring (Col. 5, lines 31-36) formed by

forming a polycrystalline copper alloy comprising copper and an additional element (Col. 5, lines 49-54 and Col. 6, lines 41-44), irrespective of whether the alloy is formed by the recited process steps or not (see explanation below), wherein

concentration of the additional element is, at grain boundaries of crystal grains composing the polycrystalline copper alloy and in vicinities of grain boundaries, higher than that of the inside of the crystal grains (Col. 6, lines 41-44), and concentration of the additional element in the crystal grains is 0.1 atomic percent or less (Col. 5, lines 49-53).

However, Andricacos does not teach that the additional element that is diffused into the copper film via grain boundaries is at least one of the claimed group. This limitation has already been addressed in claim 17 in view of Lee-850.

Further, Andricacos does not specifically teach that “a barrier metal at the interface between a barrier metal film and the polycrystalline copper alloy has not been oxidized”. This limitation has already been addressed in claim 17 in view of Fitzsimmons.

Note that claim 19 is a product claim but parts of the claim recite process limitations (similar to claim 17). Therefore, as explained for claim 17, the claim amounts to product by process limitations, which will not be given patentable weight.

Regarding claim 21, Andricacos as modified above teaches that at the crystal grain boundaries and/or in the vicinities of grain boundaries, intermetallic compounds of Cu and at least one element (Zr) are formed. Note that an alloy of two metals is essentially an intermetallic compound of the two metals.

Regarding claim 22, Andricacos as modified above for claims 17 and 18, teaches that teaches that at the crystal grain boundaries and/or in the vicinities of grain boundaries, oxides of at least one element selected from a group consisting of Ti, Zr, Hf, Cr, Co, Al, Ni, Mg, and Ag are formed.

Regarding claim 23, Andricacos (refer to Figure 3), as modified above, teaches a semiconductor device comprising a substrate (substrate of 26) on which a semiconductor element is formed, and a metal wiring (labeled Cu Alloy) composed of the copper alloy for wiring as set forth in any one of claims 17, 18, 19, 21 or 22.

Regarding claim 24, Andricacos, as modified for claims 18, 19, 21 or 22, teaches the copper alloy for wiring in any one of claims 18, 19, 21 or 22, wherein

concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries is at least 120% of the additional element concentration at the inside of the crystal grains (Col. 3, lines 44-51), and further teaches that the concentration of the additional element at the grain boundaries and in the vicinities of

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grain boundaries may approach saturation (Col. 6, lines 41-44). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries very high, such as on the order of 2 to 1000 times the additional element concentration at the inside of the crystal grains. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of approaching saturation at the grain boundaries and in the vicinities of grain boundaries (Col. 6, lines 41-44) to improve wiring properties with respect to electromigration.

Regarding claim 25, Andricacos teaches the copper alloy for wiring wherein

concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries is at least 120% of the additional element concentration at the inside of the crystal grains (Col. 3, lines 44-51), and further teaches that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries may approach saturation (Col. 6, lines 41-44). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries is very high, such as on the order of 10 to 100 times the additional element concentration at the inside of the crystal grains. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of approaching saturation at the grain boundaries and in the vicinities

of grain boundaries (Col. 6, lines 41-44) to improve wiring properties with respect to electromigration.

### ***Response to Arguments***

9. Applicant's arguments filed 04/03/2008 with respect to claims 17-19 and their dependent claims have been considered but are moot in view of the new ground(s) of rejection.

### ***Conclusion***

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AJAY K. ARORA whose telephone number is (571)272-8347. The examiner can normally be reached on Mon through Fri, 8am to 4:30pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thao X. Le can be reached on (571) 272-1708. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. K. A./  
Examiner, Art Unit 2892

/Thao X Le/  
Supervisory Patent Examiner, Art  
Unit 2892